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THE GEOGRAPHIC PATTERN OF TUBERCULOSIS IN NORTH CAROLINA

by

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I. INTRODUCTION

In 1918, there were 3,514 cases of tuberculosis (TB) in North Carolina, which is a case rate of 139.34 per 100,000 population (1). There were also 3,412 deaths from TB for a death rate of 135.30 (2). The case rate of TB has gone down considerably, however, as in 1982 it was 13.5 per 100,000 population (3). Furthermore, only 63 people died from TB in 1982 for a death rate of 1.05 per 100,000 population (4). Despite the decline in the number of cases, TB is still a serious public health problem in North Carolina. The state's case rate ranked 12th highest in the U.S. in 1982 (5). What is even more perplexing, however, is the preponderance of TB in eastern North Carolina. The map in Figure 1 clearly shows this strong geographic pattern of county morbidity rates for TB.

The major objectives of this paper are:

1) to summarize the current morbidity and health care delivery data on TB in North Carolina;
2) to provide indicators why an eastern band of counties has more than triple the TB morbidity rate of the rest of the state;
3) to see if the counties with high TB rates have high rates throughout the county or just in certain parts of the county;
4) to expand the study area and see if Virginia and South Carolina also have this eastern band of counties with a high incidence of TB.

II. BACKGROUND

The primary cause of TB is a bacterium called the tubercle bacillus (mycobacterium tuberculosis). Infection occurs through the inhalation of the organisms present in the air or droplet nuclei expelled by the coughing or sneezing of a person with active TB. The measurable manifestation of infection is a positive tuberculin skin test; however, signs and symptoms of TB may be absent. Once infected, the person's immune system usually proves adequate to limit the multiplication and spread of the bacilli. Around 5% of newly infected individuals, though, do develop TB disease within a year of their infection (6). If the bacilli produces TB in the lung, then the disease is called pulmonary TB. All other sites of TB are called extra-pulmonary TB.

Vague general symptoms such as fatigue, nervous irritability, or anorexia usually signal the onset of pulmonary TB (7). Later symptoms include a cough, a cold, blood spitting, unexplained fever and night sweats, loss of weight and swollen glands (8). The symptoms for extra-pulmonary TB depend upon where the TB develops.

Approximately 85% of the reported cases of TB in the U.S. are pulmonary TB (9). It is much more a public health problem than extra-pulmonary TB since it usually is more contagious. In pulmonary TB, a cavity is frequently formed in the lung and large numbers of virulent bacilli are released from this cavity daily. Pulmonary TB, however, is not a highly infectious disease when compared to other diseases since transmission usually requires close, frequent, or prolonged exposure (10).

Among persons infected with the tubercle bacillus, only about 5-10% ever develop TB disease (11). However, because the organisms remain viable within the body for decades, the risk of disease is lifelong. The precise factors that determine whether any infected individual will develop disease are frequently unknown, but the risk is influenced by age, sex, body build, immune status (12), recency of infection, associated illnesses, and whether preventive therapy with antituberculosis drugs has been undertaken (13). As a general rule, the risk of disease is greatest within the first year or two after infection and thereafter decreases with time. The elderly have the highest case rates, however, because many of them were infected in years past when TB was much more prevalent, and because of immune deficits associated with aging (14).

The risk of infection is influenced by frequency of contact with a person who has an infectious case, and then by factors related to the likelihood of airborne transmission of organisms such as intimacy and duration of contact, adequacy of ventilation, and the presence of ultraviolet radiation (15). In the sample of persons tested in the Health Examination Survey, there was an overall tendency for infection rates to be lowest among persons who had the most education, the highest income, the most skilled occupations, and the largest number of rooms in their homes (16). Other risk factors for infection include being a male, as they are more likely to have a wider range of contacts outside the home, and being nonwhite, as they are more likely on the whole to be concentrated in the lower socioeconomic groups with poor, crowded housing (17).

High TB rates in an area have been shown to be associated with socioeconomic conditions, the level of urbanization, and the past level of TB (18). Other factors include the percentage of foreign-born residents (19), alcoholism, and uncontrolled diabetes mellitus (20). Socioeconomic conditions that are associated with high rates of TB include poverty, overcrowded and poorly ventilated housing (21), undernutrition, poor hygiene (22), low levels of education, and a large percentage of persons in occupations classed as semiskilled or unskilled (23).

TB can be controlled today through the use of antituberculosis drugs. The treatment is usually outpatient and administered by the county health department. The department's aim is to break the chain of transmission of infection by identifying the sources of infection and neutralizing them with adequate chemotherapy. The health department must also find and treat contacts (people who have recent known exposure to TB patients) and reactors (people who have a positive tuberculin skin test but no known exposure to TB). The treatment given to them is called preventive treatment, as the aim of the treatment is to prevent the contacts and reactors from becoming cases.

To find and treat all patients early has always been and still is difficult. One problem is that those who contract the disease are often contagious before they feel ill. Another problem is that, once given the treatment, patients feel better but they still must take their pills every day for 6 to 12 months if the treatment is to be effective. Therefore, human nature being what it is, people who do not feel ill grow careless about taking pills and do not readily accept health care.

Preventive treatment has similar problems. It is reported that often people who are contacts and reactors do not feel ill and they frequently do not readily accept health care. Furthermore, preventive therapy is usually not recommended for persons over the age of 35 because the risk of adverse reactions, especially hepatitis, outweighs the risk of TB (24). Consequently, there is not much health officials can do about the large number of infected older people in North Carolina.

III. DATA COLLECTION

The sources of TB data included the North Carolina Communicable Disease Report Card, the North Carolina Tuberculosis Surveillance Report, the North Carolina Tuberculosis Control Semi-Annual Assessment Report, and the North Carolina Tuberculosis Control Epidemiologic Survey. These data sources were obtained from the Tuberculosis Control Branch of the Epidemiology Section in the North Carolina Division of Health Services. The information collected from the report cards were the age, race, sex, ethnic origin, and county of residence of the TB patient. The surveillance report provided information on employment, reimbursement of medical costs, hospitalization, institution the patient resided in at the time of diagnosis, previous reported episodes of TB and any information on the known exposure to TB. The assessment report provided data on the bacteriologic conversion of sputum, the number of patients that completed their drug therapy, contact surveillance, the continuity of preventive therapy, and the total persons under active surveillance in the health department's register. Finally, the epidemiologic survey generated data on smoking, alcohol use, employment hazards, concomitant illness, whether the TB resulted from endogenous breakdown, and whether the patient was found before he or she sought health care. The data on this survey instrument were obtained through the patient's epidemiologic record, hospital discharge record, and health department records.

Other data sources used in the analysis include the 1980 Census of Population (U.S. Bureau of the Census), the North Carolina County **Health Data Book**, the North

Carolina Leading Causes of Mortality (1981), and the *North Carolina Vital Statistics* (1980). These data sources were obtained from the North Carolina State Data Center (Office of State Budget and Management) and the North Carolina State Center for Health Statistics. Examples of items collected were per capita income, the number of migrant farm workers in a county and the age adjusted death rate in a county.

IV. METHODOLOGY

The results shown in this report are divided into two parts: descriptive and analytic. The descriptive part summarizes the current morbidity and health care delivery data on TB through the use of percentages and means. The analytic part provides indicators to help explain the geographic pattern of TB case rates mostly by using correlation coeffients and multiple regression statistics. The correlation coefficients measure the strength of the relationship between two variables. They can range from -1 to +1, with +1 meaning the variables are perfectly related by a line with a positive slope and -1 meaning the variables are perfectly related by a line with a negative slope. A correlation coefficient near zero means there is little relationship between the two variables.

The multiple regression investigates the effects of several independent variables (such as income and education) on a dependent variable (in this case the TB case rate). It differs from the correlation statistics in that it allows us to assess the combined effect of several variables, as well as the unique contribution of each variable. One of the statistics produced in the multiple regression analysis is the R^2 statistic, which indicates the proportion of the total variance in the dependent variable that is accounted for by all of the independent variables. Other statistics produced in the analysis are the standardized weights. They indicate how much change in the dependent variable is produced by a change in one of the independent variables when the others are statistically held constant. Since these weights are standardized, we can rank the variables by their ability to predict the TB case rate. The F value is another multiple regression statistic, and this is an indication of the extent to which R^2 may be due to random variation. Finally, the probability statistic (p) represents the probability of getting the observed F value simply by chance.

While multiple regression and correlation analyses are useful methods describing the relationship between the independent variables and dependent variable, there are still potential limitations that must be kept in mind. One limitation is that these methods do not prove causality. Though the results may be suggestive, these analyses do not demonstrate that a change in one independent variable directly leads to a change in the dependent one. Multiple regression and correlation analyses may demonstrate coexistence, but causality must be imputed on theoretrical grounds or demonstrated by experimental methods.

It should be noted that all of the statistics were produced by a computer program called SPSS, or Statistical Package for the Social Sciences. Furthermore, the assumptions of multiple regression such as the lack of high correlation among the independent variables and the linearity of the relationship between the dependent variable and the independent variables were tested and found to be reasonably applicable.

V. RESULTS

Morbidity Data Summary

The data from the 1983 North Carolina Communicable Disease Report Card are summarized in Table 1. It can be seen that TB patients tend to be individuals over 45 years of age, nonwhite, and male. They are also not Hispanic and are concentrated in the East and South Central regions of North Carolina. Comparing the North Carolina population characteristics to the TB patient characteristics, one can see that the TB patients are not representative of the population as a whole. For example, the 1980 Census of Population shows that the median age for North Carolina is 29.6 and that its population is 22 percent black, 51.5 percent female, and 10 percent over the age of 65.

The data from the 1983 North Carolina Tuberculosis Surveillance Report are summarized in Table 2. It can be seen that in North Carolina the persons with TB tend to be individuals who are unemployed, have no health insurance, not institutionalized, hospitalized for TB during the year, and had no previous reported episodes of TB. In North Carolina, meanwhile, the 1983 unemployment rate was 8.9 and according to the 1981 N.C. Citizen Survey, the percentage of uninsured adults was 12.0. The large percentage of unknowns in the exposure variable (item VI) shows that most people with TB do not know who exposed them to the disease. This has important implications that will be discussed later.

TB patients by age, race, and sex are shown in Tables 3 and 4. One can see that TB patients are concentrated in the older age groups and among nonwhites. If we compare the North Carolina rates in Table 4 to the 1981

United States TB case rates, the largest differences lie in the 65 and over age group. For example, the 1983 N.C total case rate for the 65 and over age group was 45.70 while the 1981 U.S. total case rate for the same age group was 29.7. The difference is even larger for the nonwhite males, as the N.C. 65 and over case rate was 237.68 while the comparable 1981 U.S. rate was 149.7. The nonwhite females age 65 and over also show a large difference: the 1983 N.C. rate was 69.65 while the comparable 1981 U.S. rate was 54.8.

The data from the two 1983 North Carolina Tuberculosis Control Semi-Annual Assessment Reports are summarized in Table 5. Item 1, concerning the bacteriologic conversion of sputum, measures the effectiveness of a health department with regard to the followup of a patient. The health department should collect monthly sputum specimens (discharges from the respiratory passages) as an indicator of compliance in taking the required medicine and to assist in evaluating the effectiveness of the medical regime. Item II, case drug completion, exhibits the compliance of the TB patients to the drug therapy. Item III, contact surveillance, measures the effectiveness of the health department's contact investigation and the health department's aggressiveness in putting people who are contacts on drug therapy. Finally Item IV, continuity of preventive therapy, exhibits the compliance of people who are contacts and reactors to preventive drug therapy.

The data in Table 5 imply that the eastern part of North Carolina is more effective in its TB health care delivery. The question arises, however, as to how North Carolina compares to the United States with regard to TB health care delivery. This question can be approached by comparing data collected by the Centers for Disease Control (last column Table 5). For the bacteriologic conversion of sputum, the percent of positive sputum culture that converted to negative within 3 months in the U.S. for 1981 was 57.2 and the percent that converted within 6 months was 72. Both of these percentages are higher than the percentages in North Carolina, implying that the U.S. is more effective in the followup of TB patients. However, the U.S. data on sputum conversion do not represent the entire U.S. as only 71.7% of all cases were included. The reason for the discrepancy is that not all states collect this type of data.

The United States percentage of TB patients who have completed drug therapy was 77.7 for 1981 patients completing within 12 months and 83.8 for 1980 patients completing within 24 months. Both of these percentages are higher than in North Carolina, where the TB patients had 24 months to complete their recommended course of therapy. This again implies that North Carolina is not as effective in its TB health care delivery. The U.S. data on completion of therapy, however, represents only 48.9% of the patients in 1980 and 61.7% of the patients in 1981.

For contact surveillance, North Carolina, when compared to the U.S., has a higher percentage of close contacts to all TB patients identified whose skin tests were read (96.20 to 92.6), a higher percentage of close contacts with a tuberculin skin test of 0-4 mm placed on drug therapy (19.86 to 14.75), and a higher number of close contacts per case (3.87 to 3.66). The United States, however, has a higher percentage of close contacts with a significant tuberculin skin test (5 mm or greater) placed on drug therapy (65.63 to 53.84). Thus, it appears that the U.S. is more aggressive in preventive therapy for the more significant tests. The U.S. data are for 1982 and represent 67.5% of the TB patients.

The percentage of reactors and contacts in the United States completing preventive therapy was 70.0 in 1981. This is much higher than the North Carolina percentage of 54.22 and it implies that the U.S. has a more effective preventive therapy policy. Unfortunately, there is no easy way of knowing what percentage of the contacts and reactors in the United States is represented in these data.

County Analysis

The purpose of the county analysis is to provide indicators to help explain the geographic pattern shown in Figure 1. Thirty-two county level variables were entered into the multiple regression equation, and it was found that four variables explain 62% of the variation in the TB rates among the 100 counties. Before using the TB rate as the dependent variable in multiple regression, the logarithm of the TB rate was first computed since the relationships between the four variables and the county TB rates are not linear. This means that, as the four variables increase or decrease in value in a county, the TB rate in that county increases or decreases exponentially rather than in a linear fashion. Since an assumption of multiple regression is that the relationship between the independent variables and dependent variable is linear, the logarithm of the TB rate was taken in order to transform the curvilinear relationship to a linear one so that the techniques of linear regression analysis could be used to measure the strength of the relationship.

The four variables from the regression analysis that together were the most important predictors of the pattern of TB across N.C. counties, with their standardized weights in parentheses, are the percentage of nonwhites in a county (.55), the age adjusted death rate in a county (.23), the percentage of the work force in a county in the manufacturing-or-related sector (-.18), and the percentage of people in a county who are migrant farmworkers (.11). The R^2 statistic was .62, the F value was 38.1 and the p value was less than .001. These results suggest that the counties with high TB rates have a combination of a high percentage of nonwhites, a high age-adjusted death rate, a high percentage of migrant farmworkers, and a low percentage of workers in manufacturing.

The correlation analysis produced a number of variables that were individually highly associated with the logarithm of the county TB rates. (The correlation coefficient also measures the strength of a linear relationship.) The four variables with the strongest associations, with their correlation coefficients in parentheses, were the percentage of nonwhites in a county (.72), the age adjusted death rate in a county (.57), the percentage of people in housing units with more than one person per room (.56), and the infant mortality rate in a county (.53). Squaring the correlation coefficient indicates the percentage of the variation in the TB rate that is explained by one variable. For example, the percentage of nonwhites in a county alone explains 52% of the county variation in TB rates.

To further investigate the discrepency in the TB case rates among the counties, the two 1983 North Carolina Tuberculosis Control Semi-Annual Assessment Reports were used to examine the differences in health care delivery. The state was divided into two sets of counties: the ten counties with the highest five-year (1978-82) TB case rates (28) and the rest of the state. The data in Table 6 indicate that the ten high TB incidence counties were more effective than the rest of the state with regard to TB health care delivery, as reported on these forms. For example, the ten counties had a larger percentage of their positive pulmonary TB patients convert to negative within 3 and 6 months, had a larger percentage of their patients complete the recommended chemotherapy, had a larger percentage of their close contacts put on chemotherapy, took less time finding the patients or suspects, and had a larger percent of their contacts and reactors complete preventive chemotherapy. The ten counties also had a smaller average number of close contacts per sputum positive pulmonary TB patient, though this was due in part to Sampson County reporting an average number of contacts per patient of only .93 compared to a state average of 4.47.

A possible reason for the better performance in the high TB incidence counties is that they are more aware of the TB problem since it is more prevalent; therefore, they invest more time and money into trying to control the problem. Another possible reason is that the documentation of the records in the high TB counties might be more complete. However, assuming that the data are accurate, the question arises as to how a county that does a more effective job trying to control their TB problem can actually have a consistently higher TB case rate?

One possible explanation is the number of migrant farmworker TB patients. Although the migrant farmworkers only comprise a small percentage of the state's TB patients, they could comprise a large percentage of people with TB in some counties. It was found that in 1983 only three of the ten high TB counties had migrant farmworker patients; however, two of the three had a rather large percentage of migrant patients. The three counties, with the percentage of migrant farmworker patients, were Sampson (50%), Johnston (23.5%), and Nash (12.5%). One may conclude from the data that migrant farmworker TB patients contribute substantially to the high TB rates in Sampson and Johnston counties, but that still does not explain the high rates in the other eight counties (29).

Another possible explanation is the number of TB patients that were endogenous breakdowns. Endogenous breakdown occurs when someone who has had TB infection for years develops the disease because their body could not contain the infection anymore. A county health department can do very little to prevent the TB disease when there are a large number of individuals that endogenously break down. The reason for this is that the risk of adverse reactions from preventive chemotherapy outweighs the benefit in infected people over 35, and it is the older persons that are more likely to endogenously break down. Consequently, the health department can only contain the incidence of TB by treating the infected people over 35 when they finally break down and develop the disease. However, if the number of individuals that endogenously break down is small, then the people with TB were the result of recent infections. This would signal an uncontrolled spread of TB. A county health department can be very influential in stopping that if they can find the source of infection and treat all recent infections. Furthermore, they can even treat the older persons who were recently infected since now the risk of TB outweighs the risk of adverse reactions (30).

The question of endogenous breakdown was addressed when the Tuberculosis Control Branch carried out an epidemiologic survey in 1983. Information was compiled from the TB epidemiology forms, hospital discharge records, and the patient writeups, all of which are maintained by the health departments for each TB patient. Twenty counties were selected in the eastern part of the state. Ten of the selected counties had higher than expected TB case rates (31) and ten had lower than expected case rates (32). Chi-square and difference of proportion tests were used to evaluate whether or not there was a significant difference between the two groups of counties in the measured variables.

Results from the survey that were statistically significant include the number of TB patients that were endogenous breakdowns and the number of TB patients that had concomitant illnesses. It was found that the low-incidence counties had a higher proportion of endogenous breakdowns, excluding the unknowns, and a higher proportion of TB patients with concomitant illnesses. However, the large percentage of unknowns in the endogenous breakdown variable (the high-incidence counties had 32% while the low-incidence counties had 16%) makes any statement about the differences in endogenous breakdowns very questionable. The data do not, however, support the idea that the higher TB rate in the ten counties is due to relatively higher endogenous breakdowns.

Other results from the survey include no statistically significant differences between the ten high-rate and ten low-rate counties in the proportion of TB patients that smoked, used alcohol, were exposed to asbestos or silica in the workplace, went to the health department for their illness, and were discovered by the health department. An interesting result from the survey was that most TB patients (90%) in the 20 counties sought health care on their own before the health departments found them. Since most people with TB usually are contagious before the severe symptoms set in, this finding is rather disturbing.

Zip Code Analysis

The purpose of the zip code analysis was to find out if the counties with high TB rates have high TB rates throughout the county or just in certain parts of the county. The ten N.C. counties with the highest TB case rates and case loads were chosen, and their TB cases were tabulated by their respective zip codes in that county. The zip code areas with a population of 1,000 or more in 1980 that had the highest TB rates are exhibited in Table 7. The rates for all of the zip code areas in the ten counties are shown in Appendix 1. If a zip code in one of the ten counties does not appear, then that zip code area had no TB cases reported.

It can be seen from Table 7 that there are zip codes with much higher TB case rates than their respective county rates. The range in zip code TB rates shown in Appendix 1 gives more evidence that there are certain "hot spots" in the high TB incidence counties. It can be argued, however, that this large range exists because some zip codes have very small populations and the TB rates are thus very unstable. But even when we eliminate the zip codes with less than a 1,000 population, the range in TB rates is large; therefore, further analysis was undertaken in order to account for these substantial geographic differences.

Correlation and multiple regression analyses were performed for the zip codes with 1,000 or more people in 1980. The logarithm of the TB rate for the zip codes was used because the relationship between the independent variables and the TB rate was again found to be nonlinear. Twenty zip code level variables were used in the analyses, and it was found that the variables that correlated most highly with the TB rate were the percentage of zip code residents 25 years and over with a high school education (-.48), the percentage of the zip code's work force in the farming-or-related sector (.43), the median rent in a zip code (-.43), and the percentage of nonwhites in a zip code (.36). Thus, the zip codes with high TB rates appear to be areas with a low education level, a high percent nonwhite, a low median rent, and a high percentage of the population engaged in farming. For multiple regression analysis, the independent variables with high standardized weights were the percentage of zip code residents 25 years and over with a high school education (-.66) and the percentage of the zip code's work force in the manufacturing or related sector (-.32). The R^2 was .31, the F value was 14.7, and the p value was less than 0.001.

It should be noted that some of the zip code TB rates are artifically inflated because migrant farmworkers are counted in the caseload but not in the population. Unfortunately, there is no easy way to subtract the migrants from the caseload or add them to the population. However, only Johnston and Sampson counties should have a substantial problem with this.

Standard Morbidity Ratios

The map in Figure 2 shows that the high eastern incidence of TB is not just a problem in North Carolina, but in Virginia and in South Carolina as well. In order to investigate this geographic pattern, standard morbidity ratios were calculated for each county in the three states. The standard morbidity ratio, or SMR, for a county is the actual number of TB patients in a county divided by the expected number of patients based on the county's age, race, and sex distribution. Each county's population was analyzed by age, race, and sex and each age-race-sex-specific population was multiplied by the United States TB case rate for that group. For example, in Alamance County the number of white males age 0-4 was multiplied by the U.S. white male age 0-4 case rate. Summing up all the age, race, and sex cells will give an expected number of patients for Alamance county. Then the actual number of patients was divided by the expected number of patients to yield the SMR. This procedure was done using data from the years 1979, 1980 and 1981 combined in order to stabilize the SMRs. The SMR values for all North Carolina counties are shown in Appendix 2.

The map in Figure 3 exhibits the SMRs for the three states. Comparing the two maps, it can be seen that most of the counties in the eastern TB belt have two to four times as many TB patients as would be expected based on their age, race, and sex composition of the population. The western part of Virginia also has a problem with TB. However, many of those counties had a small number of patients (for example, the observed number was four patients and the expected was two); therefore, the ratios in Western Virginia should be interpreted with caution. One can infer from Figure 3 that the TB problem in the east is not due just to the fact that the area has a high percentage nonwhite, which is controlled for in the SMR, but that factors other than demographic structure are causing the high level of TB.

VI. SUMMARY AND DISCUSSION

The first part of this report summarizes the 1983 morbidity and health care delivery data on TB in North Carolina. It was found that older nonwhite males had the highest case rates and most of the TB patients were in the East. Furthermore, the people with TB tended to be unemployed, uninsured, hospitalized during the year, not institutionalized, and unaware of who exposed them to TB. It was also found that the U.S., based on data collected by the Centers for Disease Control, is more effective in the followup of TB patients and has a more active preventive therapy policy.

The second part of the report analyzes the geographic pattern of three-year county TB case rates. Through correlation analysis, it was found that the TB rates were highly associated with the percentage of nonwhites in a county, the age-adjusted death rate in a county, the percentage of people in units with more than one person per room in a county, and the infant mortality rate in a county. It was also shown through multiple regression analysis that four variables (percent nonwhite, age-adjusted death rate, the percentage of the work force not in the manufacturing-or-related sector, and the percentage of people who are migrant farmworkers) explain 62% of the variation in the TB rates among the counties. The ten high TB rate counties were found to be more effective in their TB health care delivery, and the migrant farmworkers inflated only two of those counties' rates. Finally, endogenous breakdown was found to be more prevalent in the low-incidence TB counties.

The question asked in the third part of the analysis was if counties with high TB rates had high TB rates throughout the county or just in certain parts of the county. The analysis showed that some counties have zip codes with TB rates that were double and even triple the county rate. It was also shown that the zip codes with the highest TB rates also had a high percentage of residents 25 years and over without a high school education, a high percentage of work force in the farming sector, a low median rent, and a high percentage of nonwhites.

Standard morbidity ratios were constructed in the last part of the analysis to determine if the pattern of TB morbidity rates by county in Virginia, North Carolina, and South Carolina are due to the counties' demographic makeup. A map of SMRs exhibits an eastern TB belt in the three states and a western belt in Virginia. We may conclude that the counties in the eastern TB belt have very high TB rates even after the age, race, and sex composition in these counties is accounted for. In Western Virginia, however, some of the high SMRs involve small numbers and may not be stable.

The high incidence of TB in North Carolina in the older age groups was also cited in a study by Greg Samsa in 1981 (33). He divided the state up into 3 regions and found that the coastal TB case rates were in 1980 higher than the United States rates in almost every age-race-sex group. The problem is especially magnified, however, in the age groups over 45 years for both races. He also found that race is unimportant in accounting for the high eastern N.C. TB rate in the sense that the ratios of N.C. white rate/U.S. white rate and N.C. nonwhite rate/U.S. nonwhite rate were about the same. He concluded that age rather than race was the coast's TB problem. As for the rest of North Carolina, Samsa found that TB rates were slightly lower than the U.S. rates in almost every age-race-sex group in 1980. These differences, however, were much more pronounced in 1966, the first year of his study.

A result that warrants further attention in this study is the better performance in the high TB rate counties with regard to TB health care delivery. Besides being more effective than the rest of the state the ten high rate counties were about as effective as the United States. Thus, it appears that a lack of effort in the public health sector in Eastern North Carolina is not behind the high TB incidence. However, that does not mean a larger effort will not reduce the level of TB in those counties.

Another result that has important implications is that most individuals with TB are unaware of who exposed them to TB. One can imply that this signals endogenous breakdown, as the individuals were probably infected many years ago. Although the results of the epidemiologic survey indicate that endogenous breakdown is not a factor in the high-incidence counties, the large proportion of unknowns makes those results very questionable.

A result that would be very helpful in addressing the endogenous breakdown issue is infection rates per county. If a county had a large "reservoir of infection", then there would be more candidates that endogenously break down with TB disease. This would be a very expensive result to ascertain, however, as a large number of people in each county would have to be skin tested. It should be noted that the skin test records from the health departments should not be used to answer this question because the sampling procedures among the counties are not consistent.

In conclusion, it seems that this report creates as many questions as it answers. Future research is needed and several recommendations pertaining to this research can be put forward. They are as follows:

1. A special study is needed to address the question of endogenous breakdown. The TB patients from the high TB incidence counties would be the study population and all their medical records would be analyzed to determine if their condition resulted from an endogenous breakdown or a recent infection.
2. The zip code areas with the highest TB case rates need to be examined. Do these areas have more patients that were endogenous breakdowns or recent infections? Is there a health care delivery problem in these areas?
3. Health departments should target the high risk populations outlined in this paper for their TB screening programs.
4. Virginia, North Carolina, and South Carolina need to coordinate their efforts and determine what similar traits the counties in the eastern TB belt have. This study has shown that the high TB rates in some eastern and south central counties are correlated with factors other than the age-race-sex composition of the population. Although these counties tend to be very economically poor, nearby counties that are also very poor has substantially lower TB rates. Factors to be investigated should include diet, soil types, and water content.
5. More research is needed regarding TB among migrant farmworkers. Is the TB among migrant farmworkers the result of endogenous breakdowns or recent infections?
6. Variables that are not currently collected for the TB patients that would be helpful include income, education, diet, the length of time the patient had the symptoms before receiving medical attention, and the regular source of medical care the patient has.

Although TB has been recently known as a disease of the lower socioeconomic groups, that does not mean we can only wait until North Carolina develops socioeconomically before we can significantly reduce TB. We now have the medical technology to contain and even prevent TB. It is a matter of finding and treating the people who are cases, contacts, and reactors. That responsibility lies largely with the county health departments and it is hoped that the information presented in this report will in some way aid their fight against one of North Carolina's long-term public health problems.

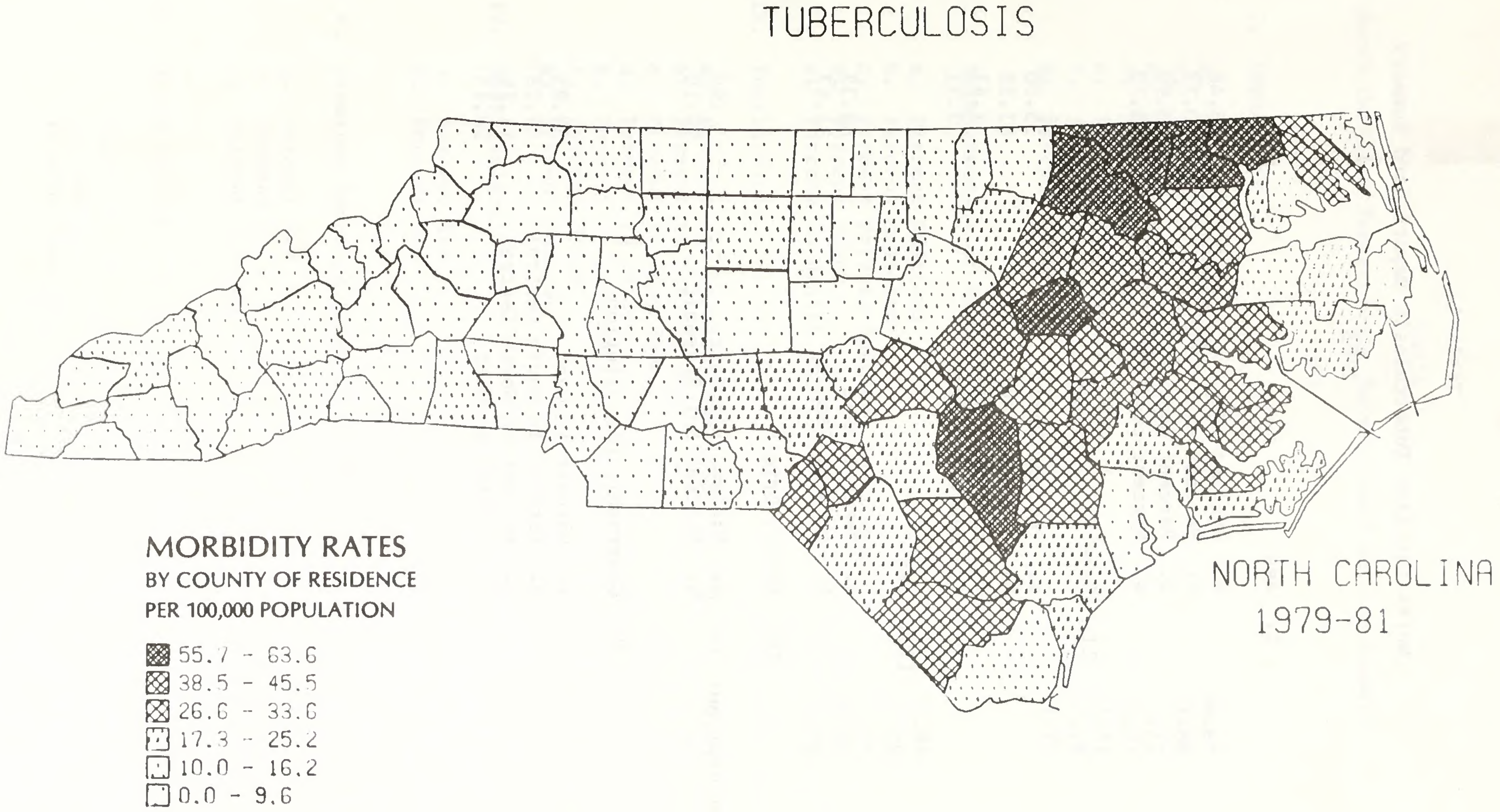
TUBERCULOSIS
NORTH CAROLINA
1979-81
MORBIDITY RATES
BY COUNTY OF RESIDENCE
PER 100,000 POPULATION
▩ 55.7 - 63.6
▩ 38.5 - 45.5
▨ 26.6 - 33.6
⬚ 17.3 - 25.2
⬚ 10.0 - 16.2
☐ 0.0 - 9.6

FIGURE 1

Table 1

North Carolina Tuberculosis Report Card Summary

1983

I.	Age	
a.	Average Age	55.46
b.	Percent over 45	70.77
c.	Percent over 55	55.90
d.	Percent over 65	38.72
II.	Race	
a.	Percent White	35.00
b.	Percent Black	61.28
c.	Percent Indian	1.41
d.	Percent Other	2.31
III.	Sex	
a.	Percent Male	68.33
b.	Percent Female	31.67
IV.	Ethnic Origin	
a.	Percent Hispanic	.90
b.	Percent Not Hispanic	99.10
V.	Geographic Distribution	
a.	Percent in East	38.85
b.	Percent in South Central	29.23
c.	Percent in North Central	11.79
d.	Percent in West	20.13

Table 2

North Carolina Tuberculosis Surveillance Report Summary
1983

I.	Employment	
	a. Percent Unemployed	48.85
	b. Percent Migrant	2.69
	c. Percent School Employee	.77
	d. Percent Student	2.31
	e. Percent Foodhandler	1.41
	f. Percent Health Care Employee	2.18
	g. Percent Other	41.79
II.	Reimbursement of Medical Costs	
	a. Percent Medicaid	8.34
	b. Percent Medicare	26.28
	c. Percent Private Hospital Insurance	13.46
	d. Percent Other	8.46
	e. Percent No Health Insurance	43.46
III.	Institutions	
	a. Percent not Institutionalized	92.18
	b. Percent in Nursing Home	1.54
	c. Percent in Rest Home	1.80
	d. Percent in Prison	2.05
	e. Percent in Psychiatric Institute	.38
	f. Percent Other	1.92
	g. Percent Unknown	.13
IV.	Hospitalization	
	a. Percent Yes	73.95
	b. Percent No	27.05
V.	Previous Reported Episodes of TB	
	a. Percent Yes	6.54
	b. Percent No	86.92
	c. Percent Unknown	6.54
VI.	Known Exposure to TB	
	a. Percent Close Contact	21.54
	b. Percent Casual Contact	6.28
	c. Percent Unknown Contact	72.18

Table 3

1983 North Carolina Tuberculosis Cases

By Age, Race, and Sex

Age	Total	White Male	White Female	Nonwhite Male	Nonwhite Female
0 - 4	12	2	2	4	4
5 - 14	8	0	1	1	6
15 - 24	38	3	1	15	19
25 - 44	170	29	14	91	36
45 - 64	251	70	22	116	43
65 +	301	83	46	119	53
	780	187	86	346	161

Table 4

1983 North Carolina Tuberculosis Case Rates

By Age, Race, and Sex

(Cases per 100,000 population)

Age	Total	White Male	White Female	Nonwhite Male	Nonwhite Female
0 - 4	2.89	1.38	1.46	6.01	6.06
5 - 14	0.89	0.00	0.33	0.70	4.28
15 - 24	3.42	0.73	0.26	9.39	12.28
25 - 44	9.40	4.22	2.03	44.14	16.03
45 - 64	21.16	15.36	4.39	114.81	33.57
65 +	45.70	39.62	14.24	237.68	69.65
	12.83	8.39	3.68	47.68	20.39

Table 5
Data From the 1983 North Carolina Tuberculosis Control Assessment Report
and
The 1983 Center for Disease Control Tuberculosis Summary Report

	State	Eastern*	Central*	Western*	U.S.
I. Bacteriologic Conversion of Sputum: 1/82 - 12/82					
a. Percent of cases with positive culture that converted to negative within 3 months:	35.53	46.99	20.57	37.93	57.22
b. Percent converted within 6 months:	58.12	68.67	45.39	58.62	72.03
II. Case Drug Completion: 7/80 - 6/81					
a. Percent of cases completing recommended course of therapy:	76.78	82.23	67.65	81.82	83.75
b. Percent of those completed who missed more than 30 days:	30.24	26.27	39.13	25.25	-----
III. Contact Surveillance: 7/82 - 6/83					
a. Percent of close contacts to sputum positive pulmonary TB cases identified that were tested:	98.05	98.67	97.95	96.21	-----
b. Percent tested that were read:	98.84	99.46	98.19	98.18	-----
c. Percent of those with a tuberculin skin test at $\geq$ 5 mm placed on drugs:	52.69	50.16	47.18	72.48	-----
d. Percent of those with a tuberculin skin test of 0-4 mm placed on drugs:	24.91	32.37	19.91	7.91	-----
e. Percent of those with a tuberculin skin test of 0-4 mm receiving 2nd skin test:	55.21	61.61	43.76	55.81	-----
f. Percent of contacts examined within 8 days:	59.57	66.97	47.77	59.76	-----
g. Percent of contacts examined within 15 days:	76.46	87.34	60.03	74.77	-----
h. Percent of contacts examined within 22 days:	81.31	91.29	63.79	84.98	-----
i. Percent of contacts examined within 29 days:	87.33	93.54	77.16	87.69	-----
j. Number of contacts per case:	4.47	5.45	3.63	4.08	-----
k. Percent of close contacts to all TB cases identified that were read:	96.20	96.87	96.04	94.50	92.57
l. Percent of those with a tuberculin skin test of $\geq$ 5 mm placed on drugs:	53.84	49.16	50.89	72.73	65.63
m. Percent of those with a tuberculin skin test of 0-4 mm placed on drugs:	19.86	28.81	13.21	6.07	14.75
n. Number of contacts per case:	3.87	4.69	3.30	3.41	3.66
IV. Continuity of Preventive Therapy: 7/81 - 6/82					
a. Percent of close contacts starting and completing 3 months drug therapy:	75.00	75.38	56.67	100.00	-----
b. Percent of reactors and contacts starting and completing 12 months drug therapy:	51.07	57.78	37.32	56.19	-----
c. Percent of reactors and contacts starting and completing drug therapy:	54.22	62.24	38.43	57.64	70.00

*Note: See references 25, 26, 27.

Note: The U.S. data are for different years than the North Carolina Data.

Note: In item 1 the cases that died or moved were subtracted from the total. In item II the cases that died, moved, or were still compliant with the therapy were subtracted from the total. In item IV the contacts and reactors that died, moved, or discontinued their medicine due to medical advice were subtracted from the total.

Table 6

1983 North Carolina Tuberculosis Control Assessment Report:

Comparison of the Ten Highest TB Rate Counties with the Rest of the State

		10 High TB Rate Counties	Rest of State
I.	Bacteriologic Conversion of Sputum: 1/82 - 12/82		
	a. Percent of positive sputum culture that converted to negative within 3 months:	51.25	31.53
	b. Percent converted within 6 months:	75.00	53.82
II.	Case Drug Completion: 7/80 - 6/81		
	a. Percent of cases completing recommended course of therapy:	82.01	75.35
	b. Percent of those completed who missed more than 30 days:	26.32	31.41
III.	Contact Surveillance: 7/82 - 6/83		
	a. Percent of close contacts to sputum positive pulmonary TB cases identified that were tested:	96.73	98.34
	b. Percent tested that were read:	100.00	98.59
	c. Percent of those with a tuberculin skin test of ≥ 5 mm placed on drugs:	62.14	50.97
	d. Percent of those with a tuberculin skin test of 0-4 mm placed on drugs:	49.82	19.02
	e. Percent of those with a tuberculin skin test of 0-4 mm receiving 2nd skin test:	65.12	52.86
	f. Percent of contacts examined within 8 days:	71.61	56.97
	g. Percent of contacts examined within 15 days:	89.32	73.68
	h. Percent of contacts examined within 22 days:	92.71	78.85
	i. Percent of contacts examined within 29 days:	96.09	85.43
	j. Number of contacts per case:	3.51	4.76
IV.	Continuity of Preventive Therapy: 7/81 - 6/82		
	a. Percent of persons completing 3 months drug therapy:	84.31	72.59
	b. Percent of persons completing 12 months drug therapy:	59.81	49.75

Table 7

1979-81 North Carolina Tuberculosis Zip Code Analysis:

Areas with a 1,000 or More Population Having a Substantially Higher TB Rate than their Respective County Rate

County	County TB Rate 1979-81	Zip Code	Town of Post Office	Zip Code TB Rate 1979-81
Johnston	42.7	27504	Benson	128.86
		27542	Kenly	63.59
Nash	43.5	27807	Bailey	77.54
		27809	Battleboro	119.64
		27882	Spring Hope	144.72
Wilson	62.7	27883	Stantonsburg	113.48
Pitt	41.0	27812	Bethel	83.41
		27828	Farmville	71.46
Northampton	61.0	27831	Garysburg	109.35
		27832	Gaston	124.03
		27869	Rich Square	83.60
Halifax	56.6	27823	Enfield	139.05
		27839	Halifax	80.88
Sampson	63.6	28334	Dunn	154.28
		28341	Faison	127.23
		28366	Newton Grove	197.76
New Hanover	21.3	28401	Wilmington	46.23
Columbus	31.2	28432	Clarendon	61.77
		28439	Fair Bluff	59.14
		28463	Tabor City	53.70
Lenoir	38.5	28551	LaGrange	49.10

VIRGINIA, NORTH CAROLINA, AND SOUTH CAROLINA
TUBERCULOSIS RATES PER 100,000
1979–1981

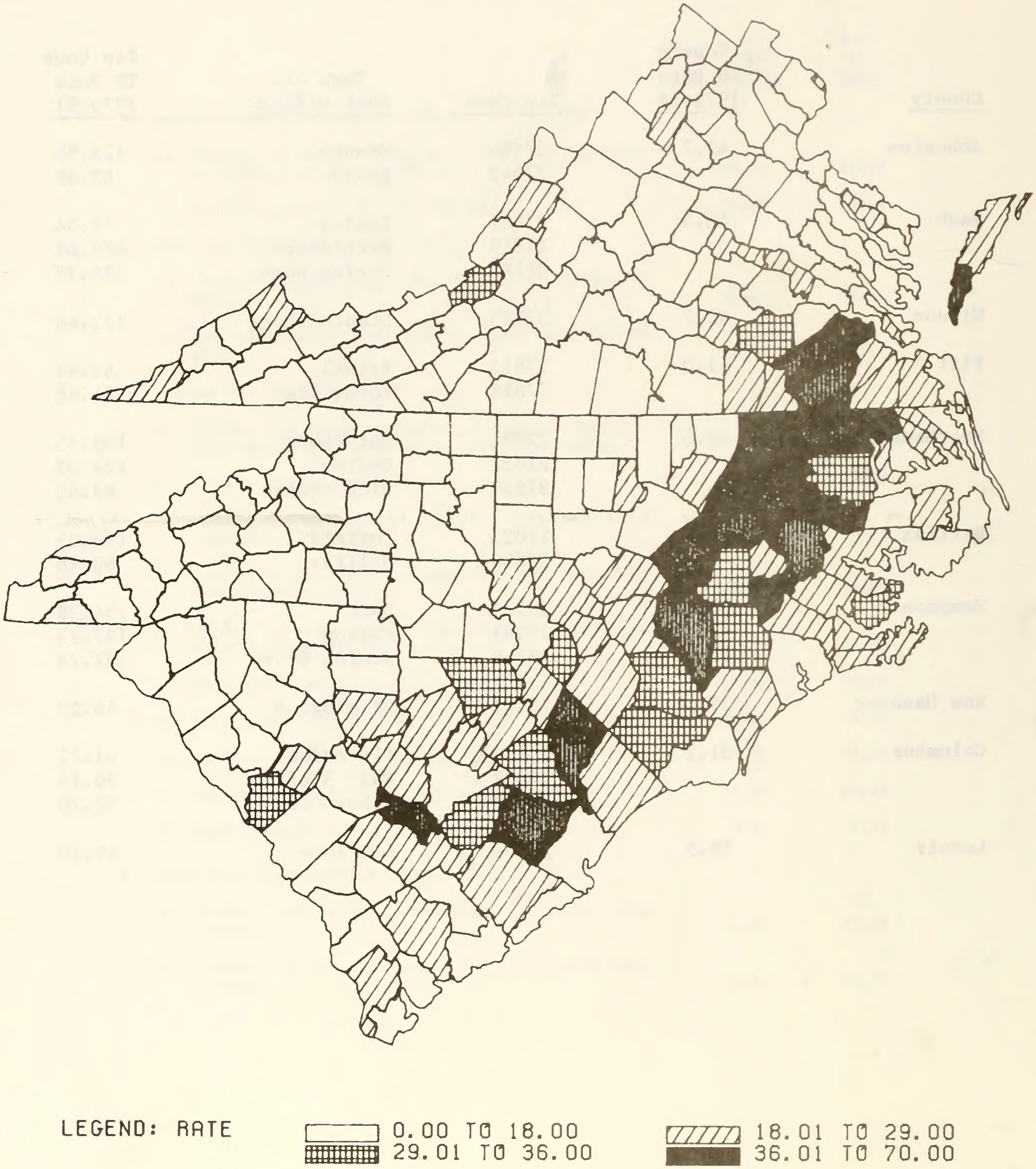

FIGURE 2

VIRGINIA, NORTH CAROLINA, AND SOUTH CAROLINA
TUBERCULOSIS STANDARD MORBIDITY RATIOS
1979–1981

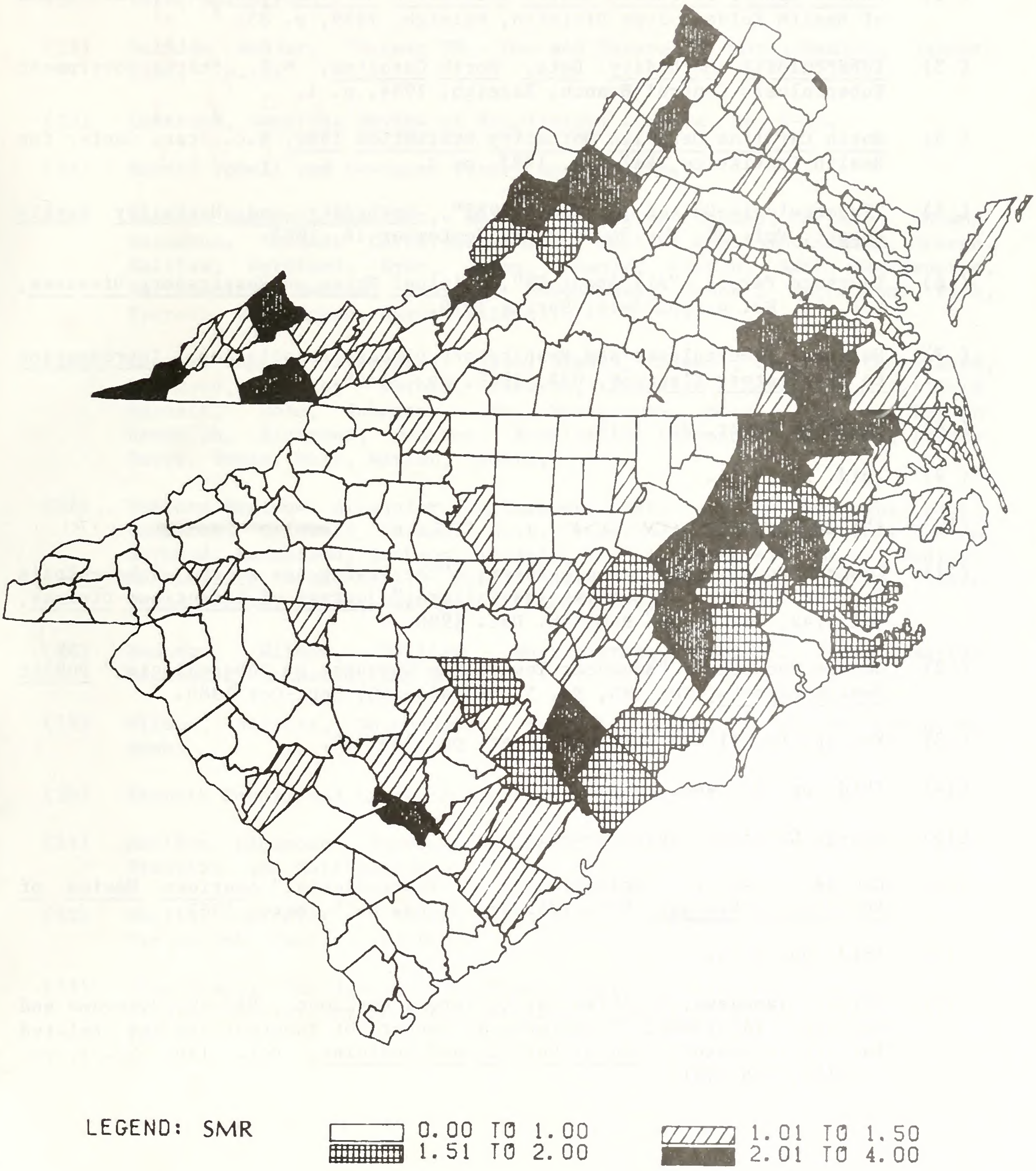

FIGURE 3

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(2) *Annual Report of Public Health Statistics Section 1958*, N.C. State Board of Health Epidemiology Division, Raleigh, 1959, p. 83.

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(5) "Tuberculosis-United States, 1982", *Morbidity and Mortality Weekly Report*, Vol. 32, No. 36, p. 479, September 16, 1983.

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(8) Lawrence Farer, pp. 3-14.

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(10) Ibid, pp. 3-14.

(11) Kenneth Powell and Lawrence Farer, "The Rising Age of the Tuberculosis Patient: A Sign of Success and Failure," *Journal of Infectious Disease*, Vol. 142, No. 6, pp. 946-948, Dec. 1980.

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(13) Kenneth Powell and Lawrence Farer, pp. 946-948.

(14) Ibid, pp. 946-948.

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(16) George Comstock, "Epidemiology of Tuberculosis," *American Review of Respiratory Disease*, Vol. 125, No. 3, pp. 8-15, March 1982.

(17) Ibid, pp. 8-15.

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(20) National Tuberculosis and Respiratory Disease Association, pp. 31-45.

(21) Ibid, pp. 31-45.

(22) Halfden Mahler, "Defeat TB - Now and Forever", *World Health*, January 1982, p. 3.

(23) Comstock, *American Review of Respiratory Disease*, pp. 8-15.

(24) Keneth Powell and Lawrence Farer, pp. 946-948.

(25) Eastern Region: Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Columbus, Craven, Currituck, Dare, Duplin, Edgecombe, Gates, Greene, Halifax, Hertford, Hyde, Jones, Lenoir, Martin, Nash, New Hanover, Northampton, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Pitt, Tyrrell, Washington, Wayne, Wilson.

(26) Central Region: Alamance, Anson, Bladen, Caswell, Chatham, Cumberland, Davidson, Davie, Durham, Forsyth, Franklin, Granville, Guilford, Harnett, Hoke, Johnston, Lee, Montgomery, Moore, Orange, Person, Randolph, Richmond, Robeson, Rockingham, Sampson, Scotland, Stokes, Surry, Vance, Wake, Warren, Yadkin.

(27) Western Region: Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Cabarrus, Caldwell, Catawba, Clay, Cleveland, Cherokee, Gaston, Graham, Haywood, Henderson, Jackson, Iredell, Lincoln, McDowell, Macon, Madison, Mecklenburg, Mitchell, Polk, Rowan, Rutherford, Stanly, Swain, Transylvania, Union, Watauga, Wilkes, Yancey.

(28) Sampson, Wilson, Halifax, Northampton, Hertford, Gates, Martin, Edgecombe, Johnston, and Nash.

(29) Wilson, Halifax, Northampton, Hertford, Gates, Martin, Edgecombe, and Nash.

(30) Kenneth Powell and Lawrence Farer, pp. 946-948.

(31) Halifax, Edgecombe, Sampson, Hertford, Wilson, Lenoir, Martin, Johnston, Franklin, and Northampton.

(32) Duplin, Carteret, Robeson, Cumberland, Brunswick, New Hanover, Craven, Pasquotank, Pamlico and Dare.

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Appendix 1

1979-81 North Carolina Tuberculosis Zip Code Analysis:

Counties with High Case Rates and Case Loads

County	County TB Rate 1979-81	Zip Code	Post Office Or Town	Zip Code TB Cases 1979-81	Zip Code TB Rate 1979-81
Johnston	42.7	27504	Benson	31	128.86
		27520	Clayton	6	19.03
		27524	Four Oaks	5	22.92
		27542	Kenly	9	63.59
		27555	Micro	1	61.16
		27569	Princeton	2	17.50
		27576	Selma	10	32.30
		27577	Smithfield	17	37.77
		27592	Willow Spring	1	37.41
		27593	Wilsons Mills	1	103.20
		28334	Dunn	1	44.27
		28366	Newton Grove	4	268.28
Nash	43.5	27557	Middlesex	4	47.76
		27801	Rocky Mount	18	17.09
		27807	Bailey	8	77.54
		27809	Battleboro	8	119.64
		27816	Castalia	2	58.94
		27822	Elm City	5	231.48
		27856	Nashville	19	55.81
		27878	Sharpsburg	1	37.29
		27882	Spring Hope	21	144.72
		27891	Whitakers	3	31.89
Wilson	62.7	27542	Kenly	2	44.10
		27813	Black Creek	1	54.56
		27822	Elm City	1	6.66
		27829	Fountain	1	109.29
		27851	Lucama	6	43.86
		27873	Saratoga	2	140.94
		27878	Sharpsburg	1	91.32
		27880	Sims	1	18.31
		27883	Stantonsburg	8	113.48
		27893	Wilson	94	70.00
Pitt	41.0	27812	Bethel	8	83.41
		27828	Farmville	15	71.46
		27829	Fountain	2	42.68
		27834	Greenville	57	33.46
		27837	Grimesland	3	41.53
		27879	Simpson	1	73.42
		27884	Stokes	1	25.20
		28513	Ayden	12	51.53
		28590	Winterville	5	42.20

County	County TB Rate 1979-81	Zip Code	Post Office Or Town	Zip Code TB Cases 1979-81	Zip Code TB Rate 1979-81
Northampton	61.0	27820	Conway	3	37.36
		27831	Garysburg	12	109.35
		27832	Gaston	8	124.03
		27845	Jackson	2	22.73
		27853	Margarettsville	1	58.69
		27862	Pendleton	2	88.77
		27867	Potecasi	2	297.62
		27869	Rich Square	7	83.60
		27876	Seaboard	2	37.24
		27897	Woodland	3	56.21
Halifax	56.6	27823	Enfield	42	139.05
		27839	Halifax	8	80.88
		27843	Hobgood	1	39.40
		27844	Hollister	2	33.59
		27850	Littleton	3	22.08
		27870	Roanoke Rapids	19	27.14
		27874	Scotland Neck	12	64.56
		27887	Tillery	1	107.18
		27890	Weldon	6	47.94
Sampson	63.6	28328	Clinton	41	63.57
		28334	Dunn	18	154.28
		28341	Faison	6	127.23
		28366	Newton Grove	18	197.76
		28382	Roseboro	6	35.93
		28385	Salemburg	3	37.92
		28444	Harrells	2	50.47
		28447	Ivanhoe	1	63.25
New Hanover	21.3	28401	Wilmington	34	46.23
		28403	Wilmington	16	11.84
		28405	Wilmington	14	21.07
		28428	Carolina Beach	1	12.60
		28429	Castle Hayne	1	6.38
Columbus	31.2	28423	Bolton	3	47.06
		28424	Brunswick	1	42.52
		28431	Chadbourn	6	28.14
		28432	Clarendon	3	61.77
		28436	Delco	1	20.51
		28438	Evergreen	1	19.68
		28439	Fair Bluff	3	59.14
		28442	Hallsboro	1	12.91
		28450	Lake Waccamaw	1	24.99
		28463	Tabor City	11	53.70
		28472	Whiteville	18	37.14
Lenoir	38.5	28501	Kinston	56	40.56
		28525	Deep Run	2	35.29
		28530	Grifton	1	14.45
		28538	Hookerton	1	208.33
		28551	La Grange	10	49.10

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Appendix 2

North Carolina's Standard Morbidity Ratios for TB
1979-1981

County	TB Cases	Expected Cases	SMR
Alamance	40	43.67	0.92
Alexander	4	7.32	0.55
Alleghany	2	2.82	0.71
Anson	12	17.41	0.69
Ashe	5	5.91	0.85
Avery	1	3.55	0.28
Beaufort	34	23.70	1.43
Bertie	21	17.39	1.21
Bladen	28	19.02	1.47
Brunswick	11	16.11	0.68
Buncombe	54	56.20	0.96
Burke	16	21.49	0.74
Cabarrus	18	32.66	0.55
Caldwell	16	18.25	0.88
Camden	5	3.36	1.49
Carteret	23	13.74	1.67
Caswell	2	13.90	0.14
Catawba	21	33.10	0.63
Chatham	7	17.46	0.40
Cherokee	4	5.38	0.74
Chowan	9	8.50	1.06
Clay	0	1.83	0.00
Cleveland	32	33.91	0.94
Columbus	49	28.59	1.71
Craven	62	33.05	1.88
Cumberland	141	115.71	1.22
Currituck	6	4.75	1.26
Dare	3	4.18	0.72
Davidson	47	36.29	1.30
Davie	4	8.45	0.47
Duplin	38	23.58	1.61
Durham	103	89.48	1.15
Edgecombe	69	38.92	1.77
Forsyth	99	112.35	0.88
Franklin	16	19.53	0.82
Gaston	33	56.36	0.59
Gates	16	7.15	2.24
Graham	1	2.18	0.46
Granville	14	23.33	0.60
Greene	13	9.90	1.31
Guilford	105	145.69	0.72
Halifax	94	40.62	2.31
Harnett	46	25.74	1.79
Haywood	13	13.06	1.00
Henderson	22	17.69	1.24
Hertford	40	19.25	2.08
Hoke	16	14.14	1.13
Hyde	3	3.66	0.82

County	TB Cases	Expected Cases	SMR
Iredell	21	33.61	0.62
Jackson	4	8.56	0.47
Johnston	88	29.69	2.96
Jones	6	6.44	0.93
Lee	19	16.34	1.16
Lenoir	70	36.40	1.92
Lincoln	7	13.19	0.53
McDowell	7	10.23	0.68
Macon	5	6.23	0.80
Madison	4	4.80	0.83
Martin	35	17.57	1.99
Mecklenburg	166	188.61	0.88
Mitchell	2	3.98	0.50
Montgomery	14	10.57	1.32
Moore	26	22.90	1.14
Nash	89	36.86	2.41
New Hanover	66	46.13	1.43
Northampton	42	19.96	2.10
Onslow	32	38.05	0.84
Orange	19	28.61	0.66
Pamlico	10	6.17	1.62
Pasquotank	23	17.30	1.33
Pender	16	14.19	1.13
Perquimans	3	6.51	0.46
Person	13	15.67	0.83
Pitt	104	46.41	2.24
Polk	1	5.11	0.20
Randolph	19	27.13	0.70
Richmond	20	22.64	0.88
Robeson	69	76.04	0.91
Rockingham	14	36.11	0.39
Rowan	35	41.50	0.84
Rutherford	11	19.37	0.57
Sampson	95	30.15	3.15
Scotland	28	18.83	1.49
Stanly	13	17.02	0.76
Stokes	7	9.79	0.71
Surry	18	17.18	1.05
Swain	4	5.30	0.75
Transylvania	6	6.68	0.90
Tyrrell	3	2.76	1.09
Union	13	26.09	0.50
Vance	14	23.68	0.59
Wake	124	128.50	0.96
Warren	8	15.27	0.52
Washington	7	9.38	0.75
Watauga	7	6.98	1.00
Wayne	86	51.37	1.67
Wilkes	2	16.48	0.12
Wilson	117	35.56	3.29
Yadkin	2	8.52	0.23
Yancey	1	4.18	0.24
North Carolina	3033	2656.92	1.14

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